Organic Matter in the Outer Solar System

Dale P. Cruikshank, Ted L. Roush, Yvonne J. Pendleton, Cristina Dalle Ore, Tobias C. Owen, Thomas R. Geballe, Catherine de Bergh, Bishun N. Khare

Many solid bodies in the outer solar system are covered with ices of various compositions, including water, carbon dioxide, methane, nitrogen, and other molecules that are solid at the low temperatures that prevail there. These ices have all been detected by remote sensing observations made with telescopes on Earth, or more recently, spacecraft in orbit (notably Galileo at Jupiter). The data also reveal other solid materials that could be minerals or complex carbon-bearing organic molecules. A study in progress using large ground-based telescopes to acquire infrared spectroscopic data, and laboratory results on the optical properties of complex organic matter, seeks to identify the nonicy materials on several satellites of Saturn, Uranus, and Neptune. The work on the satellites of Saturn is in part preparatory to the Cassini spacecraft investigation of the Saturn system, which will begin in 2004 and extend for four years.

One of the Saturn satellites, Iapetus, exhibits a unique exposure of nonice surface material that has very low reflectivity, causing the surface to appear entirely black at certain positions in its orbit around the planet. The infrared spectrum of this black surface of Iapetus has been extended into new wavelength regions in the current study, exploring a part of the spectrum that has not heretofore been seen.

In addition to other characteristics of the spectrum of Iapetus, a very strong absorption band at 3 micrometers wavelength has been revealed clearly for the first time in the new study. Models of the spectrum using organic solid materials produced in realistic simulations in the laboratory strongly indicate that the black matter on half of the surface of Iapetus is indeed organic in nature. The origin and mechanism for emplacement of the black material on the surface of this moon are unknown. The Cassini mission to Saturn will provide data that have a high probability of resolving these issues and further clarifying the apparently unique history of Iapetus.

Other moons of Saturn show similar, though less dramatic, evidence for the presence of macromolecular organic matter mixed with their surface ices, but the chemistry of the organic material appears to be different. The moons of Uranus, the Neptune moon Triton, and the planet Pluto all have black materials on their surfaces that are presumed to be organic in nature. The origins of this material are likely to be different from that on Iapetus, as well, underscoring the extraordinary variety of compositions and histories that the small bodies of the outer solar system have undergone since their formation. The study in progress at Ames, with colleagues from many other institutions, seeks to explore the nature and origin of organic matter throughout the solar system, and to explicate any astrobiological connections that emerge.

Point of Contact: D. Cruikshank
(650) 604-4244
dale@ssa1.arc.nasa.gov

AIRES—The SOFIA Facility Spectrometer

Edwin Erickson, Michael Haas, Sean Colgan

An Ames team was selected by peer review to build AIRES, the airborne infrared echelle spectrometer for SOFIA, the Stratospheric Observatory for Infrared Astronomy. The objective is to develop a facility-class spectrometer for use by the international astronomical community. AIRES will be delivered to the Universities Space Research Association (USRA), NASA's prime contractor for SOFIA, who will operate facility instruments for scientists with approved observing programs.

SOFIA is a unique airborne astronomical observatory currently under development. A Boeing 747 will be equipped to carry a 2.7-meter telescope to be operated at altitudes up to 45,000 feet, allowing infrared astronomical observations that are impossible from Earth. Being developed jointly by NASA and Deutsche Forschungsanstalt für Luft- und Raumfahrt (DLR), the German Aerospace Center, SOFIA will be based at Ames with operations beginning in late 2002.

AIRES will operate at far-infrared wavelengths, approximately 30 to 400 times the wavelengths of visible light. Therefore, it will be ideal for spectral imaging of gas-phase phenomena in the interstellar medium (ISM), the vast and varied volume of space between the stars. Measurements of far-infrared spectral lines with AIRES will probe the pressure density, luminosity, excitation, mass distribution, chemical composition, heating and cooling rates, and kinematics in the various gaseous components of the ISM. These lines offer invaluable and often unique diagnostics of conditions in such diverse places as star-forming regions, circumstellar shells, the galactic center, starbursts in galaxies, and the nuclei of active galaxies energized by accretion of material on massive black holes. AIRES will provide astronomers with new insights into these and other environments in the ISM. It will also be useful for studies of solar system phenomena such as planetary atmospheres and comets, and a variety of other astronomical problems.

AIRES development began in November 1998. The design incorporates the world's largest monolithic "echelle" grating (see figure 1), an optical element that will provide good spectral resolution at far-infrared wavelengths. Two-dimensional infrared detector arrays will be used to simultaneously measure spectra in numerous locations on the sky, and to verify the location on the sky where the instrument is acquiring data. During the past year, many significant milestones have been reached, including the following: (a) the optical design has been completed; (b) the echelle grating has been fabricated; (c) the detector data system has been fabricated and tested with the imaging array detector; (d) the baseline project resource requirements have been redefined and the management revised; and (e) an external preliminary design review team, selected by USRA, has approved the project for continued development.

Point of Contact: E. Erickson
(650) 604-5508
erickson@cygnus.arc.nasa.gov

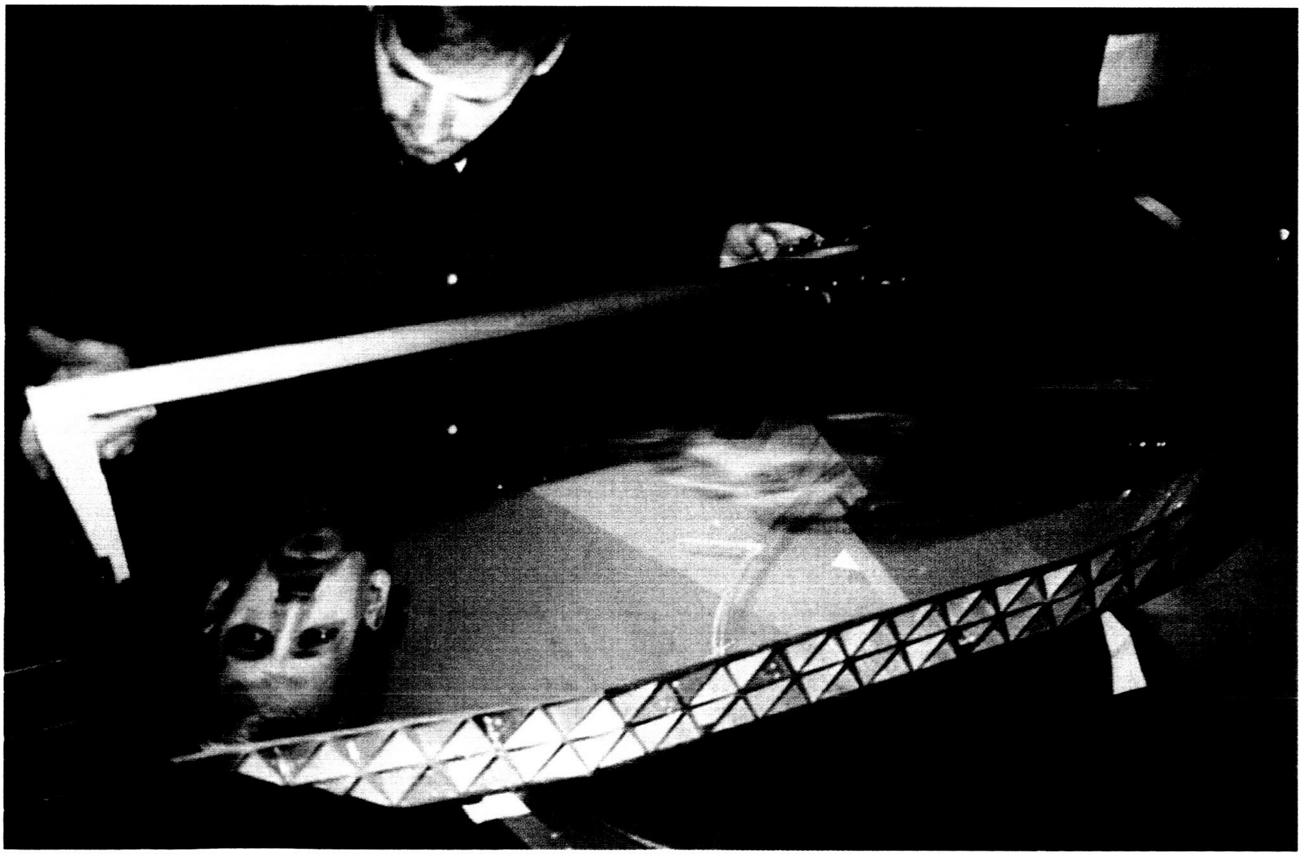

Fig. 1. The ruled echelle grating. Two images of the optical engineer are seen reflected from the facets of the grooves that are at angles of 90 degrees from each other.